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DEPARTMENT OF THE ARMY

OFFICE OF THE QUARTERMASTER GENERAL

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THE APPLIED ENVIRONMENTAL RESEARCH PROGRAM

OF THE

DEPARTMENT OF THE ARMY

ANNUAL REPORT

JUNE 1962

QM RESEARCH & ENGINEERING COMMAND

NATICK, MASS.

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FOREWORD

This report, prepared by the U.S. Army Quartermaster Corps, is the eighth in a series of annual reports, presenting information on the status of applied environmental research within the Department of the Army. Accomplishments achieved during the period from 1 July 1961 to 30 June 1962 are summarized in fulfillment of responsibility for primary cognizance for research and development in the field of applied environmental research, assigned to The Quartermaster General by Department of the Army Memorandum, 10 June 1949, File CSGLD/F1 28507, Subject: Assignment of Research and Development Cognizance in the Fields of Cryological Phenomena, Meteorology, and Environmental Research (Appendix 1), and extended by D/F, 30 June 1952, File G4/F2 41949, Subject: Transfer of Six Army-Wide Environmental Research Projects to The Quartermaster General (Appendix 2). This report on applied environmental research, as defined in the memorandum referenced above, is prepared in compliance with R&D Directive No. 335-1, O/CR&D, 24 May 1961.

The assistance of the Chemical Corps, Corps of Engineers, Ordnance Corps, Medical Service, Signal Corps, and Transportation Corps is gratefully acknowledged.

THE APPLIED ENVIRONMENTAL RESEARCH PROGRAM OF THE DEPARTMENT OF THE ARMY

1. Introduction

This report presents a review of the accomplishments in applied environmental research within the Department of the Army during the fiscal year ending 30 June 1962. Responsibility for its coordination with the Technical Services and its final preparation was carried out by the Quartermaster Corps under its primary cognizance for the field as defined and assigned by the General Staff, U.S. Army (Appendix 1).

In applied environmental research, the environmental factors are studied to provide information that must be considered in seeking solutions to the Army's logistical problems. A searching examination of the environment is necessary for adequate designing, realistic testing, development of sound field doctrine, and successful action of men in the field. The environment must be considered by scientists and engineers in traversing a polar icecap, in launching rockets, and by soldiers in guerrilla fighting in dense tropical forests. The success of these varied projects, like other Army activities, depends in large part upon the use made of environmental facts in developing materiel and doctrine.

The environmental research and development program of the Army is carried out by all Technical Services and USCONARC, individually and through cooperative effort. Coordination is achieved through meetings of the Army Committee on Environment on which all Technical Services are represented; the Army Scientific Advisory Panel; and the Army Research Office, Office of the Chief of Staff. In addition, there is frequent exchange of ideas through conferences and correspondence at all levels.

Two major aspects of Army environmental research and Army development include: (1) discovering the nature of the environment; (2) developing materiel that will function properly under all environmental stresses in protecting soldiers and helping them achieve success in battle. Obviously these two aspects of study are closely related. Although a sharp line of demarcation between them is not always evident, most of the research in the first category is done by earth scientists (geographers, climatologists, meteorologists, terrain analysts, ecologists, etc.) and that of the second is more likely to be done by engineers. All the Technical Services are committed to development and testing of materiel and its use by soldiers in all environments; research on the environment *per se*, on the other hand, is carried out by the Quartermaster Corps under its primary cognizance, though major contributions in certain aspects are made by other Technical Services.

In fulfilling their research responsibilities, Army scientists utilize all available sources of information. They must keep informed of new and important developments in their fields in this country and throughout the world. Professional journals are a major source of information. In addition, contacts are maintained with other scientists through attendance at scientific meetings, exchange agreements, correspondence, and visits to scientific institutions. For example, during the past year one geographer presented a paper at the International Geographical Union Regional Conference in Southeast Asia in Malaya. Other earth scientists presented papers at scientific meetings or conferences in various parts of the country, including three at the annual meeting of the Association of American Geographers in Miami. By promoting their status as an active part of the scientific community, Army scientists are able to build and maintain a staff of competent personnel, secure the cooperation of outstanding authorities as consultants or for contract work, keep their own research up-to-date with recent developments, and avoid wasteful duplication of work that has already been done.

The remaining portion of this report summarizes the principal efforts of each Technical Service. Some of the studies reported herein are mentioned only briefly because they are continuing, previously-reported projects; others are discussed more fully to provide an explanation of the research undertaken, to give appropriate background in some instances or to furnish more information for better understanding. Thus the length of discussion is not necessarily indicative of relative effort in the various areas of research. However, in all areas, special attention is directed toward sifting out pertinent new facts or promising ideas that pertain to Army environmental problems, digesting them into usable documents and manuals, and incorporating the information into better design and use of materiel.

2. Chemical Corps

The Chemical Corps continued its program of environmental testing at sites located in each of the five major world climates. The sites are at Fort Greely, Alaska (Arctic); Yuma Test Station, Arizona (Desert); Camp Century, Greenland (Polar); Fort Clayton, Canal Zone (Tropic); and Army Chemical Center, Maryland (Temperate). They are administered from the Chemical Corps Proving Ground, Dugway, Utah.

As established by Army Regulations, the environmental testing program provides assurance that Chemical Corps materiel has an all-weather capability. The program determines the ability of the items to withstand storage and to function adequately in worldwide environments. There are currently 29 items in the test program.

Chemical Corps personnel took part in Project Swamp Fox, which was administered by the Transportation Corps. The objective of Chemical Corps participation was to obtain preliminary qualitative information on the rate of smoke-cloud travel and dispersion under the jungle canopy.

Because polar construction methods and survival techniques stress the use of available materials in the construction of shelters and fortifications, the penetration of aerosols through snow has been investigated to determine its effectiveness as a microparticulate filter. Varying pressure differentials, such as might result from extreme meteorological conditions, were created within a test chamber by means of a variable, measured differential pressure system. Full details will be published in DPG Technical Report 330.

In an effort to establish an optimum length of environmental field testing, a study was made of the results of the old regime (5-month intervals over a 45-month period). This study showed that half of the deficiences in Chemical Corps materiel were reported during the first year of testing, and 95 per cent by the end of the second year. Further research of the remaining 5 per cent deficiencies indicated that major discrepancies could exist. Based on this study, a 2-year regime including 7-cyclic tests with an optional confirmatory test after the 2-year period was established. For example, if an item enters test on 12 May, it would again be tested on 28 July, 12 October, 28 December, and 12 March of that year; then again on 12 August and 12 February of the following year. On the basis of these tests a final report is prepared and a confirmatory test is scheduled. If the results of the confirmatory test significantly change the findings previously reported, an addendum of the new findings is prepared and distributed.

The Chemical Corps Environmental Field Testing Division has adopted Automatic Data Processing (ADP) to facilitate the correlation of environmental effects on Chemical Corps materiel during storage and functioning at the five test sites. Meteorological parameters measured hourly by Signal Corps meteorological teams at each site have been entered on punch cards since May 1961 by U.S. Army Electronic Proving Ground, Fort Huachuca, Arizona. This procedure generates annually over 8,700 cards per site, or about 43,800 each year from the five sites. Test data from functioning test items are also entered on punch cards. The application of ADP will make it possible to correlate different storage and functioning parameters with environmental effects. In this way, it is believed that much earlier reporting and correction of deficiencies can be accomplished. Chemical Corps items of proven environmental reliability can thus be furnished the Armed Forces.

3. Corps of Engineers

a. Trafficability and Mobility Research

The Waterways Experiment Station (CE) continued making trafficability and mobility studies of off-road movement of military vehicles (Project 8S70-05-001). Special attention is being directed toward the development of instruments and techniques for direct and remote measurement of the support characteristics of various materials of the earth's surface and under various environmental conditions. This research was expanded to include muskeg areas and tropical soils. A study of electromagnetic means to include radar has also been added to scan and define surface properties.

Mobility research dealt primarily with the motion of pneumatic tires through sand, the configuration of a moving tire, and the distribution of pressures under the tires at the surface of contact with the ground. This research is aimed at determining more accurately the behavior of various earthy materials and snow during the movement of vehicles over these surfaces. The new knowledge provides bases for the rational design of combat vehicles with maximum cross-country capability in specified environments while fulfilling stipulated requirements in armor and firepower.

b. Military Evaluation of Geographic Areas

The Waterways Experiment Station continued the study of correlations between environmental characteristics and military performance, and the development of methods for describing and comparing areas with respect to the environmental factors affecting performance of military tasks (R&D Task 8S70-05-001-06). The major objective then is to develop methods of classifying and comparing geographic areas in terms of the effect of the natural and man-modified environment upon military activities. Three principal lines of approach have been followed to accomplish these aims:

(1) Surveys of various sources of information have been made to determine how the environment has affected wartime operations as well as peacetime maneuvers and tests. Sources include World War II and Korean War operational records of troop units, user test reports, and maneuver reports.

(2) Research has been carried out to develop objective systems for describing and classifying environmental factors, including surface geometry, surface composition, vegetation, hydrology, and climate. Although much work remains to be done, mapping of areas is permitted in a sufficiently significant and consistent manner to allow quantitative comparison of noncontiguous geographic areas regarding their impact on military operations.

(3) Analogs of the test sites at Yuma, Arizona; Fort Churchill, Canada; Fort Greely, Alaska; and the Canal Zone have been prepared for various world areas which demonstrate quantitatively the degree of similarity to each type area. Using the climatic studies of the four sites prepared by the Quartermaster Corps, the QMC, in cooperation with the Corps of Engineers, had completed previously climatic analog studies comparing each site with other world areas. Terrain analog studies are being made by various CE organizations and by universities or private research organizations under contract. Major progress in the development of suitable terrain classification systems has been made in respect to vegetation and surface geometry. Studies to develop suitable classification systems for hydrologic characteristics and surface roughness are in progress.

The Corps of Engineers plans to participate in vehicular tests at Yuma and in Panama in cooperation with the Transportation Corps. These studies will utilize and test the terrain classification and mapping techniques developed under the overall project.

c. Climatic and Atmospheric Physics

The Cold Regions Research and Engineering Laboratory (CRREL) has a continuing in-house and external research program in progress on visibility and sound transmission in a snow and ice dominated environment (Project 8S66-02-001).

The University of Michigan has continued to study the effect of scintillation or atmospheric shimmer on visual resolution over snow and ice, and Cornell Aeronautical Laboratory has conducted further studies on the physical processes involved in whiteout dispersal. The University of Alaska has been given a grant to undertake basic research on formation of ice fog during low temperatures. CRREL scientists have continued a program of study of the distribution of visible and infrared radiation in snow and ice dominated environments in conjunction with the major research on visibility and recognition problems in cold regions (Fig. 1).

At New York University, wind tunnel studies on scale models in a simulated blowing snow environment have produced excellent data. These data were used in design criteria for heat exchanger installations at the several arctic and antarctic nuclear power plants. Field studies on drifting snow have led to the adaptation of simple, metal snow fences that are sectionized and portable (Fig. 2). They control snow drifting and accumulating in and around materiel supply dumps, nuclear power ventilator stacks, and under-snow camp entrances.

Figure 1: Measuring the visible and near infrared radiance of the sky and snow surface in a polar whiteout.

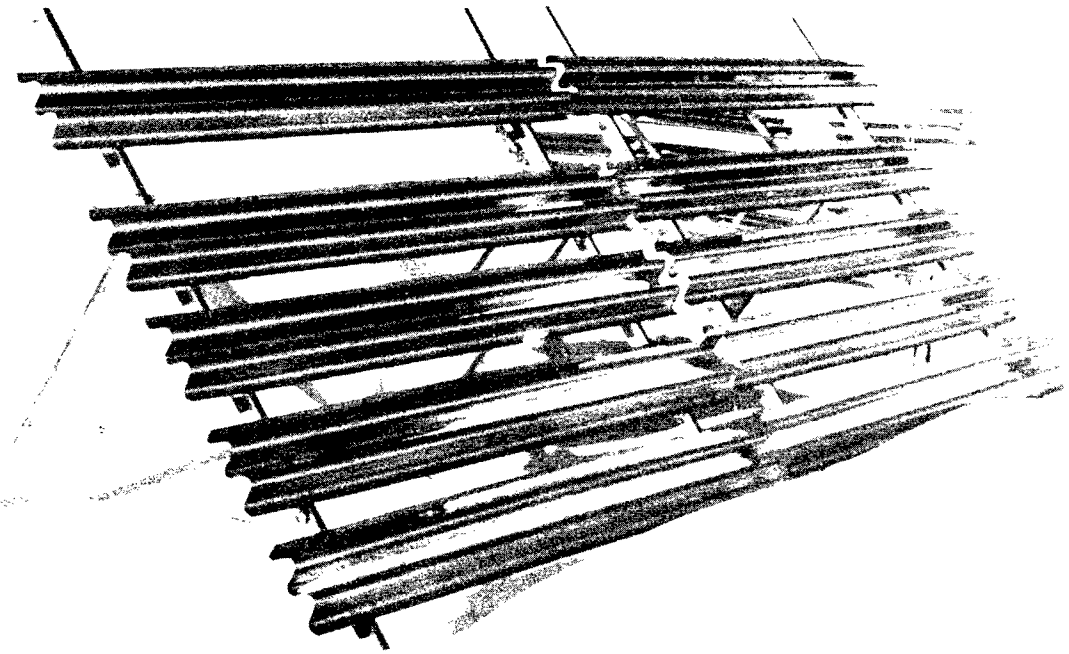

Figure 2: Two sections of the light-weight portable drift fence used in snow drift control systems developed for arctic regions.

d. Related Program

The Engineer Research and Development Laboratories (ERDL) is installing a glycol cooling sink utilizing a Rodriguez-type well at Camp Century, Greenland (Project 8S66-02-001-03). During the summer 1962, tests will be made to determine how the glycol cooling method meets requirements needed for the PM-2A Nuclear Power Plant. Test results of the heat sink method of cooling will be compared with the present method of using air blast coolers in the final reports.

Other applied environmental projects consisted of:

(1) Snow Tunnel Maintenance Equipment. The walls and ceilings of covered snow trenches constructed in the Arctic close in gradually, reducing the tunnel dimensions and ultimately crushing the buildings inside the tunnels. To prevent closure, equipment for cutting back the walls and ceilings has been developed and fabricated at ERDL and is being tested at Camp Century. Since closure advances at a greater rate near the building eaves, a carriage-mounted, electric-powered rotary cutter with aluminum track mountable on barracks was designed and fabricated to remove these growth formations. The snow and ice accumulated by periodic cutting of the walls and ceilings can be removed satisfactorily from the tunnels by a blower and pipe system. A new blower system and ice crusher for breaking up large chunks of snow are being tested.

A contract has been made with industry for a second concept or approach to a solution to the snow tunnel maintenance problem.

(2) Lead Shielded Protective Cab. A lightweight, lead-shielded, protective cab capable of providing 1 1/8 inches of lead protection and capable of being easily installed on a crawler tractor was designed and fabricated. The cab was mounted on a Caterpillar D-7 tractor and tested under desert conditions at Yuma, Arizona. The tests indicated that the lead had a tendency to flow, and the lead glass became fogged. Modifications are being made to the cab to correct the deficiencies.

4. Medical Service

The Army Medical Service carried on physiological research on heat, cold and altitude adaptation in human subjects and animals; the studies were conducted in climatic chambers and in the field. No applied environmental research, as defined for purposes of this report, was conducted.

5. Ordnance Corps

a. Climatic Field Tests

The Ordnance Corps conducted field exploratory investigations under planned environmental RDT&E programs. Arctic testing was carried out in the winter; desert testing in summer. The tests provided opportunity to observe and evaluate component materiel, major item components, and major end items under consideration or in production. The data are also correlated with tests made by USCONARC and with reports received from combat areas. Carefully planned programs are devised to put each component to the most rigorous performance possible, consistent with service requirements. Test agencies used were as follows:

(1) U.S. Army Ordnance Climatic Test Detachment, Fort Wainwright, Fairbanks, Alaska. Armament and ammunition items comprised 13 programs, and automotive materiel comprised 6 programs.

(2) U.S. Army Ordnance Test Activity, Yuma Test Station, Yuma, Arizona. Armament and ammunition items comprised 15 programs, and automotive materiel comprised 4 programs.

(3) U.S. Army Arctic Test Board, Fort Greely, Alaska. Similar items comprised 2 programs in each category.

b. Index of Environmental Factors

Aberdeen Proving Ground continued work on the bibliographical index known as the "Ordnance Technical Index of Environmental Factors," under contract with the Southwest Research Institute (Environmental Research Section). Revisions are being prepared for publication in FY 1963.

c. Environmental Research

Major environmental research was conducted under contracts with the Southwest Research Institute (Environmental Research Section) and Stanford Research Institute (Physics Department). Funding support was also maintained for a related whiteout dissipation contract (DA-11-109-ENG-100) with the Cornell Aeronautical Laboratory through CRREL, Corps of Engineers.

(1) Environmental Factors of Wet Tropics

The Southwest Research Institute is preparing a report on "Environmental Factors Existing in a Wet Tropical Environment." This study will emphasize the severe limitations on the performance of Ordnance Corps equipment in the wet tropics, such as difficulties encountered on wet soils and steep slopes.

(2) Synergistic Effects in Combined Environments Testing

The Stanford Research Institute is developing a method for analyzing simultaneous occurrences of environmental factors. Synergistic effects occur only with the concurrent application of two or more environmental stresses in testing operations.

The character of those environmental elements which affect testing operations is being analyzed by high speed computers. Machine application to actual environments requires knowledge of geographical location, immediate surroundings, and status of a test unit. It is planned to use machine operations in comparing various environmental combinations with coded lists to determine the types of interaction which occur in nature.

(3) Analog Overlay Maps

Work continued on a request by ARO for developing analog overlay maps of Yuma and other environmental test stations to show the performance ratings of environmentally sensitive combat items. Selected performance data for the M48 Tank, M35 Truck, and M274 Weapons Carrier were used because of their reasonably complete test history. Vehicle performance under a designated weather condition can be defined within a reasonably close tolerance, but vehicle performance over varied terrain is inadequately established.

(4) Modeling Technique for Weapon Foundations

A study is being made to develop a modeling technique applicable to the design of weapon foundations. This requires a complete investigation of accurate soil properties, techniques and equipment for measuring accurately the properties selected, and a dynamic modeling facility adaptable to the needs of the Ordnance Weapons Command. Since the accurate specification of pertinent soil properties is of fundamental importance, major effort has been directed toward selecting and developing ways of measuring significant soil properties. These activities have been coordinated with Ordnance Tank-Automotive Command and Waterways Experiment Station (Corps of Engineers). The tentative definition of soil properties adopted is considered pertinent at this time. It is believed that the Bevameter, as developed by the Land Locomotion Laboratory, Detroit Arsenal, will be extremely useful in measuring some of the soil parameters. An oscillating weight soil test apparatus and a soil drop test rig have been designed; construction of these devices is proceeding. Similarities of various soil classes are being investigated to provide usable model criteria for each soil class.

(5) Terrain and Vehicle Performance Evaluation

The Ordnance Tank-Automotive Command obtained measurements of snow strength and profile properties on the Greenland Ice Cap during July and August, November, and March. Preliminary snow strength evaluations were also accomplished in Alaska. Instrumentation comprised the Bevameter, with its penetration and shear tests, and the profilometer. This equipment was mounted on polecats, weasels, and M113's. The reported snow strength on the Ice Cap was an obstacle to vehicle performance, but the rough profile on the fringes of the Ice Cap was a definite deterrent. In Alaska, much work will be required to fully evaluate the terrain because of great variation of soil conditions with respect to seasonal changes.

In the United States, similar measurements of soil strength and geometric profiles were made at Aberdeen, Maryland; Fort Knox, Kentucky; Quantico, Virginia; Vicksburg, Mississippi; Yuma, Arizona; Fort Eustis, Virginia; and Houghton, Michigan. Emphasis in the immediate future will be concentrated on attempts to relate physical properties of the soil to vegetation, mineral content, climate, and landform types.

(6) Rain Investigations

Rain investigations are being made to determine the best way of simulating natural rain characteristics in a laboratory. Rain characteristics are being studied at the Frankford Arsenal's test facility for various rain rates up to 24 inches per hour and the facility is being used to measure raindrop sizes and size distribution. The raindrop observations will be compared with Law and Parson data for natural rainfall. An attempt is being made to produce raindrop sizes varying from 1/2 to 6 millimeters in diameter. Other methods of measuring raindrop size and distribution such as sooted screens, oiled panels, oiled interfaces, and high-speed cameras, are being attempted. These findings will be used in establishing methods and procedures for exposing military equipment to simulated rain testing which will be consistent with the effects of natural rain.

(7) Sunshine Investigations

The Frankfort Arsenal has been experimenting with a combination of lamps and reflectors to simulate approximate natural sunlight, one of the most difficult environments to reproduce in a laboratory. Although the total intensity of solar radiation can be produced by a large bank of lamps in a reflective chamber, no commercial lamp will simulate solar radiation in both total intensity and spectral distribution.

Research investigations have indicated that true spectral distribution of solar radiation can be obtained from a combination of filtered incandescent flood and mercury vapor lamps. A newly designed device was assembled and is being used to determine the true spectral distribution from the combination of lamps.

(8) Ozone Investigations

The Frankfort Arsenal has been investigating the interaction effects of ozone with other environmental stresses. Although the characteristics of ozone at normal temperatures are fairly well known, little information is available on the effects of changes in humidity and particularly pressure (including vacuum) on the concentration of ozone in the atmosphere. The effects of ozone in these environments are significant in the development of ground and airborne military equipment. To adequately evaluate such equipment, design criteria for suitable ozone test facilities must be developed. Such facilities are only available for testing at or near ambient temperature.

Various methods for generating ozone were investigated. Its generation by photosynthesis using an ultra-violet lamp proved to be a good method. Results of testing verify that ozone concentrations decrease when temperature increases, absolute humidity remaining constant.

(9) Environmental Analysis of Foreign-Made Materiel

The development of a system for environmental analysis of foreign-made materiel was started in November 1961. This involves a careful examination of foreign intelligence to correlate and define those related performance-environment factors considered useful for evaluation of equipment. An introductory paper in the subject area is being prepared for the Second Symposium on Environmental Research to be held at San Antonio, Texas, in September 1962.

6. Quartermaster Corps

a. Regional Research

In regional research as used in this report, geographic and climatic principles are used in analyzing, classifying, and mapping environmental complexes of specific parts of the earth's surface. In applied environmental research, the Department of the Army is most concerned with regions of extreme environments, which are most likely to cause difficulties in the field: the polar, mountain, humid tropic, and desert areas. To understand these areas it is often necessary to go into the field and study the environment firsthand. During the year, the emphasis in regional research was on polar and humid tropic environments.

(1) Southeast Asia Environment:

Indiana University is preparing under contract four climatic reports of Southeast Asia. They are: (1) mountain temperature gradients in Burma, (2) high winds in the Philippine Islands, (3) fog and other atmospheric obstructions to visibility in Malaya, and (4) precipitation regime in Thailand. Each of the studies will contain up-to-date summaries of the characteristics of the climatic element investigated and its regional distribution. The final reports, based mainly on field investigations in 1960-1961, are in the final stages of preparation. These reports will include original instrument traces and observations of peculiar phenomena.

Additional field studies of precipitation effectiveness, evaporation, and run-off are being conducted in Thailand to supplement the amount of data collected during the contract period.

As a result of field investigations in Burma, a new contract was awarded to Dartmouth College for additional climatic research in that region. This contract provides for an analysis and printing of an unpublished meteorological manuscript and other data obtained from the archives of the Union of Burma Meteorological Department for a 75-year period.

The University of Michigan completed and published under contract a report, Analysis of Geographic and Climatic Factors in Coastal Southeast Asia (32). The report contains considerable information on the environment of a 50-mile wide strip around the coast of Southeast Asia from Pakistan to China. The coastal areas and offshore waters are included for Burma, Thailand, and Malay Peninsula, and the countries of former French Indo-China. The contractor investigated the environmental elements considered essential in the design and operation of all

types of military equipment. These elements are presented in topical form with some regionalization of appropriate individual elements. Topics included are offshore water depths, coastal analysis, land surface with separate studies of relative relief and slope angles, climate and weather with detailed statistics of some weather stations, vegetative cover with a special study of trafficability of rice paddies in Malaya, soils described by separate countries, a quantified study of the road system with an interesting new technique for appraisal, and native animals and diseases of importance to military operations. Textual information is frequently supplemented by quantitative analyses in those parts of the report where the data lend themselves to quantification.

At the request of the Army Research Office, a special report was quickly prepared and published, entitled: Notes on Some Environmental Conditions Affecting Military Logistics in Thailand (24). This report, prepared from sources available at the QM R&E Center, contains information on the climate, food resources, insects, and dangerous animals. The two fundamental seasons of Thailand, wet and dry, are differentiated. Average annual rainfall varies from 40 to 180 inches; differences in intensity and in dates of beginning and end of the rainy season fluctuate strikingly from year to year and place to place. Although Thailand is relatively warm all year, both the hot and cold extremes occur during the dry season. Figure 3 is one of the 20 illustrations from this report, showing the need for different camouflage colors in different parts of Thailand during the dry season. It is planned to expand this report to include other aspects of the environment.

(2) East Asia Environment

A study of the relationship between the environment of East Asia and the soldier as well as between the environment and military materiel has been started. The study area includes all the Asiatic mainland south of the Soviet Union and east of the 90th meridian, except India and Pakistan. The principal offshore islands included are Taiwan and Kyushu (Japan). The study will stress operational difficulties due to the environment, such as in storage, food and water requirements, and mechanical limitations in particular areas of the East Asian region. This project consists primarily of compiling data for map and other graphic presentation, following the format of Technical Report EP-118, Southwest Asia: Environment and Its Relationship to Military Activities. Progress to date includes a search for source materials, delimitation of the study area, selection of base maps, and environmental phenomena that will be mapped.

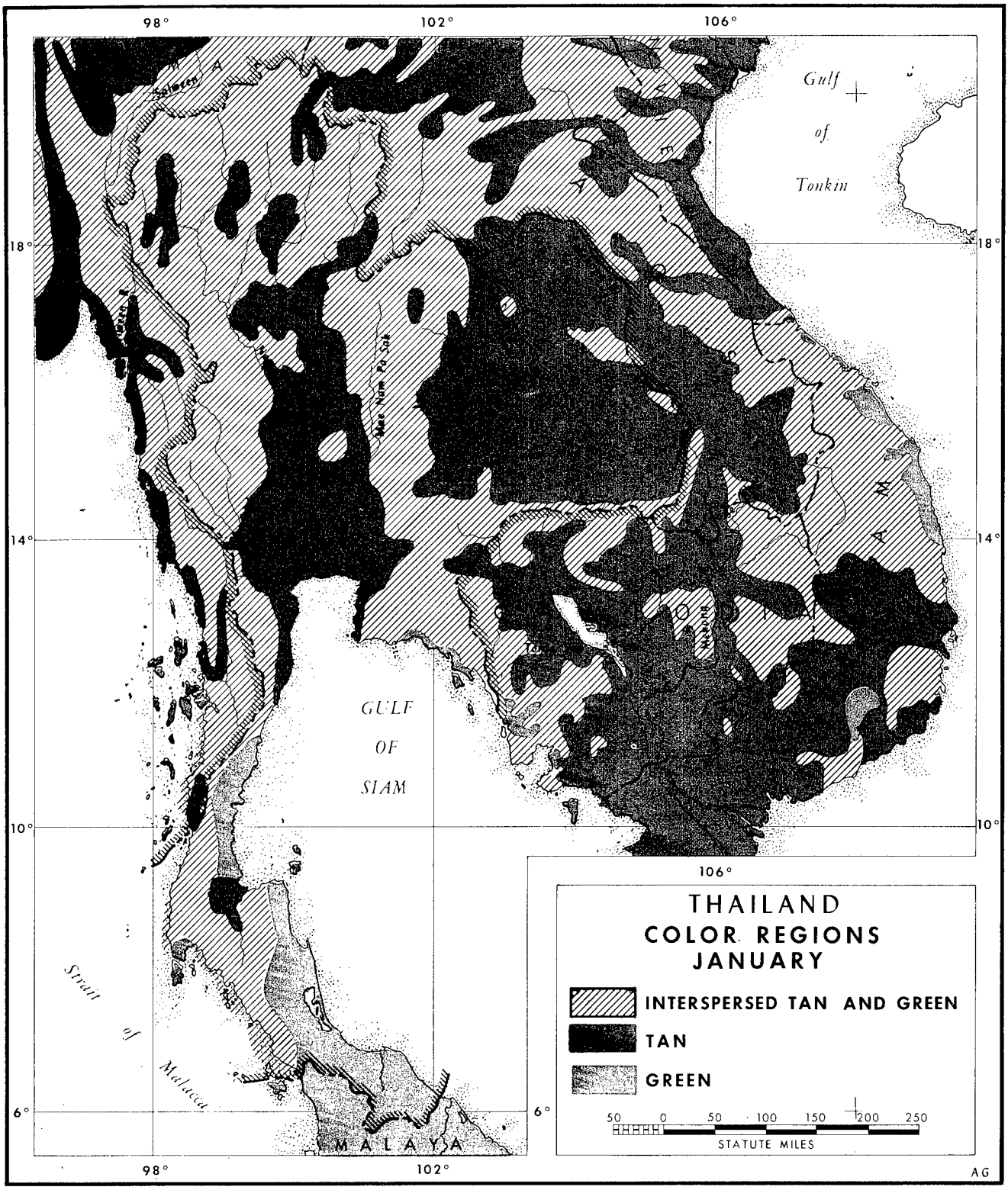

Figure 3: The January color map shows areal camouflage requirements for two standard Army colors, tan and green. Tan represents areas of sand or thin mountain soils, harvested cropland, and broadleaf deciduous trees during the dormant season. Green represents broadleaf evergreen trees and deciduous trees during the rainy season. Munsell 7.5 YR 6/6 is the approximate color nomenclature for tan, and 5 GY 4/5, for green. In parts of the mountainous regions areas of evergreens alternate with those of leaf-shedders.

(3) Greenland Environment

Because of Greenland's increased strategic and scientific importance in recent years, the island was divided into four convenient regions for study: the Ice Cap, Southeast, Southwest, and North Greenland. The publication of the Southeast Greenland study was previously reported. The second study, "Environment of the Greenland Ice Cap," is awaiting final editing and reproduction. Most of the research and part of the text for the Southwest Greenland study, third in the series, is finished. This comprises all the western ice-free area south of the 75th parallel.

The North Greenland study, fourth and final study in the series, was started. It includes the northern ice-free littoral from the 75th parallel (including Thule) on the northwest coast to Scoresby Sund on the east coast (71°N. lat.). Over half of the ice-free area of Greenland is in this remote, bleak, but militarily strategic region. As in the two completed reports, current studies will provide data and information for realistic advance planning for protection of the soldier and development of logistical scientific expeditions. The study will emphasize the militarily significant aspects of climate, terrain, vegetation, coastal features, and ice conditions. A substantial amount of this information, published since World War II, is combined with better known basic facts. Useful data extracted, in part, from many not readily available foreign sources are also presented in more usable form.

(4) Environmental Handbooks of Army Test Sites

Since 1953, the Quartermaster Corps has prepared a series of twelve handbooks describing the environment of Army test sites, particularly those representing extreme environments. The handbooks, based on library and field research, provide descriptive, tabular, and graphic information on climate, topography, ground conditions, and vegetation. Although the series of reports has a similar format, emphasis is on the more severe environmental aspects characterizing each test site and on those features considered most useful to test planners. The availability of essential facilities and some special features useful in test planning are described briefly.

These handbooks are for the test sites at Yuma, Arizona; Mt. Washington, New Hampshire; Whittier, Alaska; Dugway, Utah; Fort Lee, Virginia; Fort Churchill, Canada; Big Delta, Alaska; Devils Lake, North Dakota; Fort Sherman-Fort Gulick, Canal Zone; Thule, Greenland; Natick, Massachusetts; and the Camp Hale and Pikes Peak areas, Colorado.

The thirteenth handbook in the series, Fort Wainwright (near Fairbanks), Alaska, is in preparation. Its contents and format will be similar to previous handbooks. The analysis will include meteorological data gathered over the past 50 years.

b. Topical Research

Topical research involves the study of individual factors in the environment, such as microclimate, radiation, insect distribution, or food geography.

(1) Microclimatic and Mesoclimatic Studies

Microclimate concerns the detailed climatic structure of the air space from the surface of the earth upward to a height where local surface effects on climate are negligible. Macroclimate pertains to a large-scale climate over a large area. Mesoclimate is intermediate between a highly detailed study of a station site and a more generalized study of a large area like Alaska. Mesoclimatic studies usually involve the use of standard observations for topographic or landscape areas varying from a few acres to several square miles, as of a small valley bottom or a hillside.

Antarctica: Reduction and analysis of micrometeorological measurements taken by the Quartermaster Corps as part of the USNC-IGY Glaciology Program at Little America V (1957) and at the South Pole (1958) continue at the QM R&E Center. An additional National Science Foundation grant was awarded during the year to help support this research, which is administered by the Ohio State University Research Foundation. At Little America V, 1,145 hourly wind profiles and approximately 3,000 temperature profiles were measured on 157 days and 150 days, respectively; at the South Pole 1,416 hourly wind profiles and approximately 8,750 temperature profiles were measured on 303 days and 278 days, respectively. Wind profiles included measurements of speed in centimeters per second at six heights (50 cm. to 8 m.), and temperature measurements on the Celsius scale for nine heights, surface, and seven depths within 8 meters of the surface. The hourly and daily data from the wind and temperature profiles at the South Pole were published (10), including a brief text describing the program, the station and its general climatology, instrumentation, data reduction system, and the presentation of data.

These data are being analyzed to (1) determine the interrelationships between wind and temperature profiles during strong inversions over a uniformly smooth and extensive area, (2) compute the vertical transfer of sensible heat and relate it to the general meteorological and surface conditions, and (3) determine the climatology of the 8-meter layer adjacent to the snow surface.

Canal Zone: U. S. Army Electronic Proving Ground, Fort Huachuca, Arizona, is reducing data from strip charts to punch cards for two stations in the Canal Zone. The data are from microclimatic observations made by the Signal Corps at two stations in the zone, Coco Solo and Miraflores. Both areas are used for testing. The data are needed for further analysis of microclimates in different tropical environments and to enable QMC scientists to provide essential details of wet tropical environments to clothing and equipment designers.

Puerto Rico: A contract was negotiated with the Institute of Tropical Forestry, Rio Piedras, Puerto Rico, to analyze data from seven microclimatic stations on the coast, mountain slopes, and the top of the mountain near the eastern end of the island. The temperature, humidity, precipitation, dew point, and wind data were gathered by Signal Corps over approximately a 2-year period, ending March 1961. At three of the stations, data were obtained from ten levels to a height of 2 meters. The analysis is to (1) determine daily and seasonal temperature gradients, (2) differences in climatic elements from station to station (mesoclimate), and (3) predictable patterns in these station differences to show possible principles of mesoclimatic variation. This micro and mesoclimatic study will provide valuable statistical information concerning the environment of the soldier and his equipment at various heights above the ground and also at different heights above sea level in a rugged tropical mountain. Performance capabilities and needs for special equipment in this area and perhaps other similar places may be determined from the analyzed data.

Fort Greely, Alaska: The mesoclimatic study of temperature differences in the Fort Greely, Alaska, area was completed and presented at the Alaska Science Conference (37). The results are based mainly on data obtained from a network of 25 stations operated by the Signal Corps (1954-1957). The stations were erected in diversified environments, including representative terrain and vegetation types, in an area about 18 miles long and 12 miles wide in the Alaskan interior (Fort Greely area).

The distribution of cold during extremely cold periods was mapped to demonstrate the significant variation of temperatures in the area and the inadequacy of the Big Delta FAA standard weather station at Fort Greely for many testing purposes. The lower sites had daily minimum

temperatures during the colder periods 10 to 15 F degrees lower than the minima recorded at the permanent FAA station, including Bolio Lake where much winter testing is done. Since the occurrence of the lowest temperatures often varies appreciably among the lower areas, the making of observations in several areas may be advisable to take full advantage of extremely low temperatures for some critical tests. Some higher sites, a few miles farther south, had no temperatures below -35 F during the three years of record, compared to an extreme minimum of -50 F at the FAA station during the same period. During summer, temperatures among the stations are more uniform.

Voluntary Meteorological Observations: Standard weather observations by volunteer observers, using equipment provided by the Quartermaster Corps under no-cost loan agreements, were continued at a wildlife sanctuary in Massachusetts and at Barbados, West Indies, by McGill University. Although similar agreements with three observers in the Natick area were canceled, the 3 to 4 years of data for each station will assist QMC climatologists in answering inquiries concerning local climatic variations in this area.

(2) Radiation Studies

The solar and terrestial radiation measurements made by the Signal Corps at Natick since January 1956 were transferred to the Maynard QM Test Activity (12 miles from Natick). The measurements include incoming longwave and shortwave solar and sky radiation of all wavelengths at the surface of the ground. Similar measurements were made for the Quartermaster Corps by Signal Corps meteorology teams at Yuma Test Station and Fort Huachuca, Arizona, and at Fort Clayton, Canal Zone. These observations are part of a QMC program to investigate the heat balance of the earth's surface and its effect on men and field equipment.

At Maynard measurements were also made of the solar energy received on a flat surface facing south at 45 degrees from the horizontal in the following wavebands: 2,750 - 5,300 A*, 5,300 - 6,250 A, 6,250 - 6,950 A, and 6,950 - 30,000 A. Similar spectral band equipment was maintained through support of the Signal Corps and Weather Bureau on the 13,000-foot summit at the observatory of Mauna Loa in Hawaii and at sea level near the base of the mountain. Both the Maynard and Mauna Loa spectral band data are used to support QMC studies of materiel deterioration.

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*Abbreviation for angstrom, which equals 10^{-8}cm or 10^{-4} microns.

A climatic study of solar radiation in the Intermontane Region of western United States was completed (1). Temporal and areal variations of daily solar radiation received on a horizontal surface are described in detail and related through regression and correlation to such major controlling environmental factors as sunshine duration, cloud cover, atmospheric water vapor content, optical air mass*, elevation above sea level, and the presence or absence of a snow cover.

A major purpose of the study was to investigate the relationships between solar radiation, which is measured at relatively few locations, and those more commonly observed variables as possible bases for predicting solar radiation for times and places lacking radiation data. The most important of the independent variables proved to be sunshine and cloud cover, with the former almost always providing closer regression relationships for both daily and monthly data. Other variables, when added to either sunshine or cloud cover in multiple regression forms, produced some good effects, but only in the case of snow cover was the improvement of sufficient magnitude to be useful in predicting solar radiation.

To fulfill a twofold need for simplicity and accuracy, a simple linear regression relationship (of the form $y = a + bx$) between daily sunshine and insolation proved to be the best method of estimating daily values of solar radiation for computing monthly means. However, since the regression coefficients a and b of the regression equation are functions of latitude and station elevation, predictions can be improved by substituting a latitude and elevation factor for a and b in the basic equations. Through use of this method an original solar radiation network of a few stations can be used for all stations in an area from which sunshine and cloud cover data are available. In the Intermontane Region this amounted to the addition of 16 stations to the basic network of 10 radiation stations (Fig. 4). Plans have been made to apply this technique to the preparation of detailed solar radiation maps for North America and other parts of the world.

Illumination data are even more limited than solar radiation data. A paper published on this subject (2) presents a method for estimating frequency distributions of daily values of illumination from solar radiation data.

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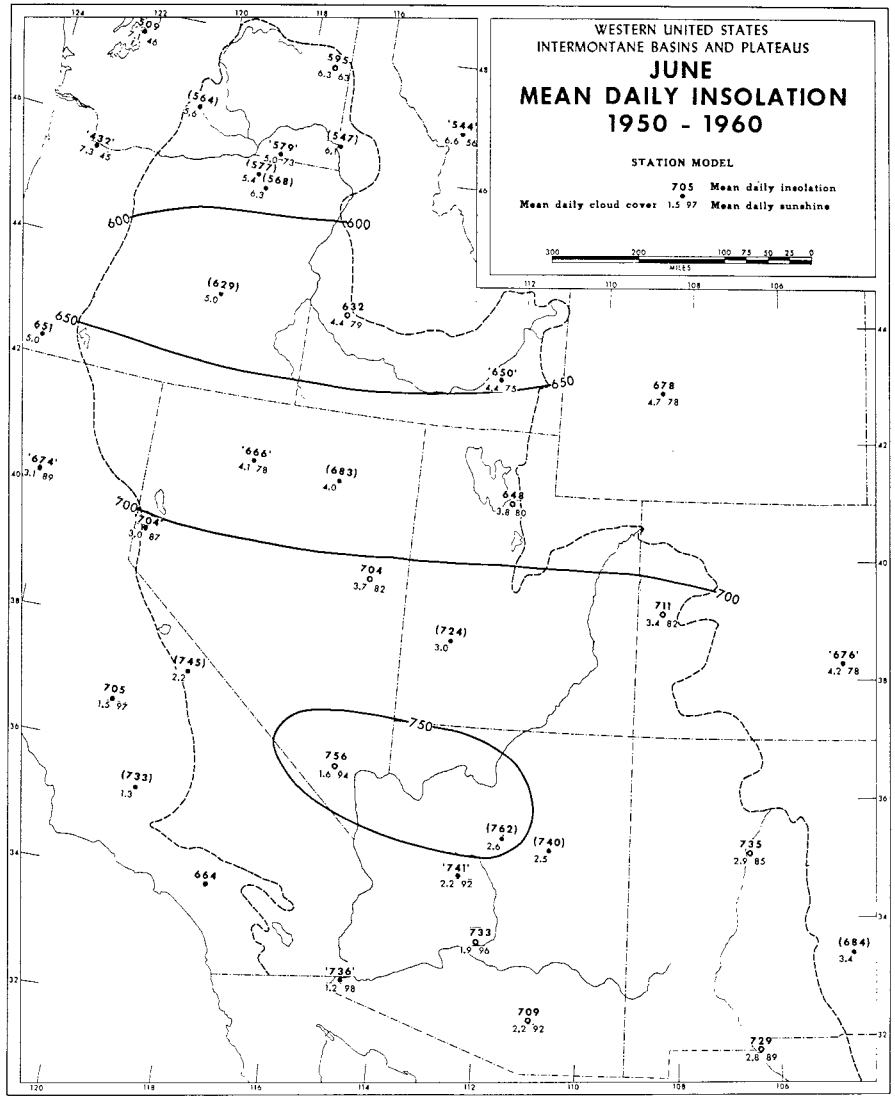
*Defined as the length of the atmospheric path traversed by the sun's rays in reaching the earth.



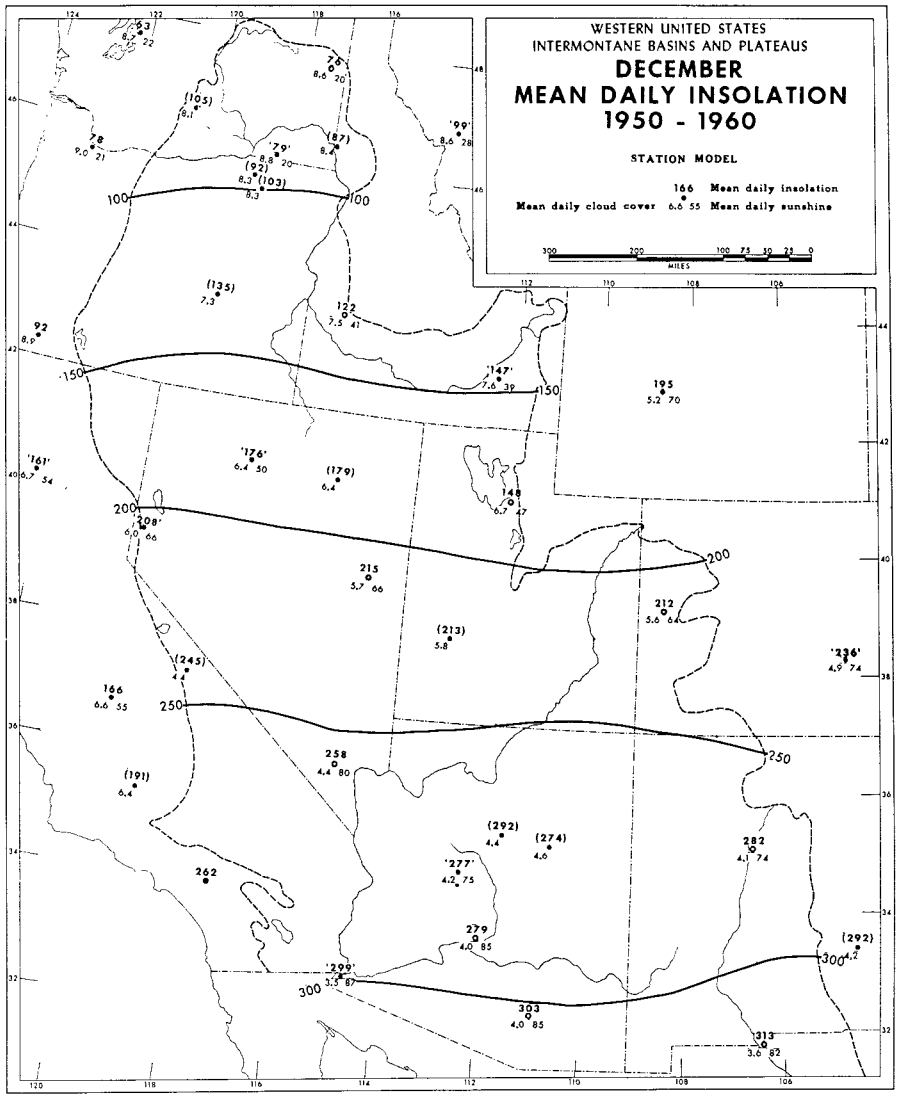


Figure 4: Insolation values are given in langleys (1 langley = 1 gm cal/cm^2/min).

(3) Climatic Frequency Data

Because climatic averages are not sufficiently realistic for certain military or scientific purposes, the question frequently arises as to how often a climatic condition may occur in a given area or place during any time of year. During 1960-1961, a series of nine frequency publications on temperature and wind speed in the colder parts of the Northern Hemisphere was completed.

This year the Air Weather Service, U.S.A.F., completed a bivariate frequency tabulation of temperature in 2-degree classes versus dewpoint in 2-degree classes for each month of the year by Beaufort wind speed classes for 150 stations in the low latitudes between 35°N. and 35°S. C-E-I-R, Inc., Boston, Massachusetts, began working on a contract to (1) collate, analyze, tabulate, and publish the frequency data by temperature and dewpoint classes, (2) prepare the resulting distributions in atlas form, and (3) evaluate additional information obtained from application of new techniques of analysis to the data.

The data, atlases, and textual information will be useful to research, development, and engineer personnel in the design and development of equipment. The publications will also be useful to test planners in the selection of optimum periods for tests or other military activities. Although some of the data are available in various forms, their application to military problems is restricted until they are uniformly processed and made readily available.

(4) Insect Distribution Studies

Insects and other species of arthropods that affect the health and comfort of man in the U.S.S.R. are being identified under a contract awarded to Cornell University. This study, similar in scope to former contracts covering Africa, North and South America, Australia, and southern Asia, calls for the abstracting and consolidating of information by species on geographical range, seasonal presence, breeding habitat, disease relationships, and population density from the world literature. These data are being coded on punch cards, and after the literature for the U.S.S.R. has been processed, they will be summarized into reports for the major divisions of the country. After the completion of this study in 1963, one will be able to learn within minutes what information on troublesome species in any part of the country is available.

The geographic index of the classification and coding system used for these studies, which contains 335 major geographical entries and numerous administrative subdivisions to which data are coded, was revised to include recent changes in the political status and country

names of several areas. The classification and coding system and the punch card that was specially designed for recording the various categories of information on insects are described in a recently completed draft for a technical report, now being prepared for publication. This report will be useful to several military and civilian agencies, which have been applying the information furnished by these contracts to studies concerned with various aspects of the insect problem.

(5) Food Geography

A final report, The Ecology of Malnutrition in the Far & Near East, was published (12). This book was prepared by the American Geographical Society under contract. The report contains up-to-date information on agricultural practices, principal farming areas, and major geographic limitations on food production in each country. The report also describes the kinds and sufficiency of food produced; food exports and imports; diet types; methods of food processing, storage, and packing; and nutritional disease patterns. Numerous statistical data in tabular form are given in the text for each country.

The same contractor started research on a similar contract of food studies of the Balkan countries and central Africa.

(6) Camouflage Atlas

In cooperation with the Waterways Experiment Station, Vicksburg, Mississippi, the drafting for publication of 72 maps with color overlays was started. These maps show extent of snow cover and color of vegetation and terrain for each month in each continent. The atlas will provide a ready color guide for personnel responsible for camouflage planning.

The maps were previously prepared and photographed for limited distribution by the Camouflage Branch, Engineer Research and Development Laboratories, Fort Belvoir, Virginia.

(7) Mountain Environmental Studies

The strategic significance of mountains as a base for guerrilla warfare has become increasingly evident in recent years, as in Cuba, Laos, and Viet Nam. Rough terrain provides relatively secure bases for troops that make small but effective raids on adjacent areas, and poses a barrier to the use of mobile equipment in counter military operations. Thus, a better understanding of mountain characteristics is required.

Studies are continuing to develop a better understanding of mountain environments of the world by relating slope morphology to climate. Criteria used are derived primarily from field and photo interpretation of terrain produced mainly by processes of weathering and erosion. Other considerations include vegetational response to climate and, occasionally, climatic data from observed or adequately described sites.

Figure 5 shows two distinctly different mountain environments developed under two different sets of climatic conditions that characterize broad areas beyond those shown in the photographs. This contrast in environment affects significantly the requirements for clothing, equipment, and other needs during operations in these areas or in analogous mountain environments.

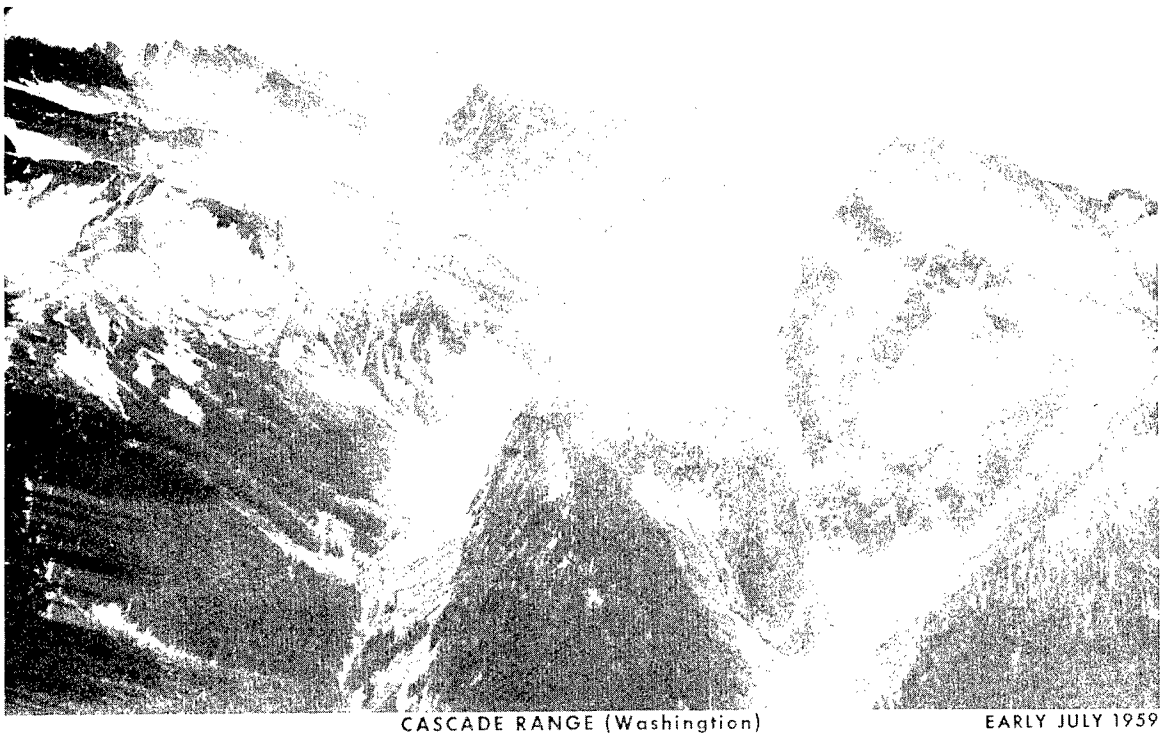
The two regions studied in detail differ strikingly in climate; study of geomorphic processes active at their alpine and subalpine levels indicates that climate is fundamental to the natural organization of mountain environments and is the key to their analysis. Each of the regions has a characteristic landscape, even on varied geologic structures; only climate could produce the regional environmental homogeneity shown in the photographs. Special attention is also being given to some foreign mountain regions that have a similar appearance and that are believed to have had climatic histories paralleling those studied in this country.

Findings published in the open literature include a 3-part study on the detailed analysis of the role of climate in New England mountain environment (6). The study pertains to climate-sensitive geomorphic processes and their long-term and current effects on the landscape of the New England mountains. A paper was also completed presenting major conclusions concerning field work in the Cascade Range (Cascades) of northwestern United States (45). This work applies the same basic principles to the Cascades and the New England mountains. Although both mountains are in the same latitude, their environments are in sharp contrast.

Plans have been completed for working out further the clima-geomorphic and other environmental principles on which a classification of mountain environments can be built and for completing such a classification and presenting world mountain information on the basis developed.

(8) Temperature Profiles of Hawaii

A review was made of the literature on rainfall and temperature of the Island of Hawaii. Rainfall distribution and its causes were studied in detail. The chief causes of rainfall are (1) orographic



CASCADE RANGE (Washington) EARLY JULY 1959

MT. KATAHDIN (Maine) LATE JUNE 1961

Figure 5: Views above represent normal mountain landscape in two strikingly different climatic regions. Past and current landscape development in these regions has been closely studied. The role of climate is important; that of geomorphic "age" is secondary. Studies indicate that every known type of mountain climate tends to develop a regionally characteristic landscape. Classification of mountain environment on a climatic basis is a promising means of organizing and presenting information about such terrain.

lifting of the trade winds, (2) orographic lifting of sea breezes on some leeward slopes, and (3) large-scale convergence, such as tropical storms or migrating cyclonic storms during winter. Although fewer temperature data are available from the upper mountain slopes, reasonably accurate profiles were constructed by using the data from the higher stations in conjunction with some upper air soundings made on the east coast of Hawaii. This research will furnish guidance for future climatic work in the region.

c. Methods and Techniques

(1) Quantitative Terrain Research

Research in this area is being conducted both by contract and in-house. Contract funds were provided by the Army Vehicle Environmental Research Team (AVERT), and inter-Technical Service effort financed mainly by the Transportation Corps.

Under contract, Mt. Holyoke College furnished a supply of data on the gaming of a line-of-sight model designed to predict the number of valleys visible at various distances from a specified high point in 15 physiographic provinces of the United States. In the areas where gaming was conducted, relief ranged from a few hundred feet to nearly 10,000 feet; average slope varied from 1 to 30 percent. The performance of the model in some regions was improved through the use of a table of correction factors for each mile from the viewing point, based on the elevation-relief ratios (ER) of the terrain. Thus, ER is an index of the openness or constriction of valleys. A low ER applies to areas with wide valleys separated by peaks and ridges; a high ER indicates areas with narrow valleys and broad uplands. In terrain with low ER, visibility from peaks to valley bottoms is better than from one with a high ER ratio.

The ER is computed according to the formula:

$$ER = \frac{E' - L}{R}$$

where E' is the average elevation, L is the lowest elevation in the total sample, and R is the relief. The elevation-relief ratio has theoretical limits between 1 and 0. The present model is nearly 85 percent accurate in its estimates of the proportion of safe and protected valleys within a radius of 20 miles. Most of the residual error is presumably due to site peculiarities of the places used. An average of more gamings within a physiographic province would probably show a higher accuracy in the predictions.

The data on up-and-down components of nap-of-the-earth flying were furnished by Clark University by contract. These data are identical earth cross-sections drawn at scales of 1:250,000, 1:20,000, and one intermediate scale. Analyses of the data indicate that if individual valley depths, spacings, and side slopes are divided by the means for the same area, the difference in the statistical distribution of the three terrain dimensions is slight. This knowledge may be used to simulate more realistic earth cross-sections. The same information will have meaning for design criteria of low-flying aircraft and suggests training and tactical doctrine for pilots.

A contract with Cornell Aeronautical Laboratory was completed (15). The report shows how to quantify human visibility factors, search doctrine, parameters of aircraft flight, illumination, target-background contrast, earth-surface configuration, and height and distribution of vegetation for greater observer efficiency. These data were used in a mathematical model and gamed with possible observer missions on an electronic computer. The results show that the model was sensitive to changes in most of the inputs. A field test should help determine how it can be simplified for use in military operations.

(2) Predicting Maximum 1-Day Precipitation

A simple method was developed for estimating maximum 1-day precipitation. It consists essentially of a multiple nomograph. This device makes it possible to predict with fair assurance the 1-day maximum precipitation likely to occur in any month from 1 to 100 years. The only data required are mean monthly precipitation, absolute 1-day maximum, and length of record.

The nomograph consists of three sections: (1) the Basic section was constructed from 10-year records of 10 widely-distributed stations in North America; (2) the Extrapolated section represents the projected trends that appear in the Basic section; (3) the Duration section is used with any length of record for prognostic purposes. Fixed values on the nomograph may be entered on a table to make manual prediction easier, or entered on punch cards for machine processing.

In Figure 6, the 1-day maximum precipitation predicted for Boston, Massachusetts, is compared statistically and graphically with the actual values based on 10-, 35-, and 86-year records for January and July. Predictions computed from each of these records are shown for periods of 10, 50, and 100 years. Maximum recorded or predicted 1-day precipitation increases with length of record. As expected, the maximum 1-day precipitation, based on the 86-year record for July at Boston, is 6.11

PREDICTED 1-DAY MAXIMUM PRECIPITATION FROM RECORDS OF DIFFERENT LENGTHS

Boston, Mass.

Month	Recorded 1-Day Max.		Predicted 1-Day Max.		Maximum Amount Predicted For Indicated Number Of Years (INCHES)
	Yrs.	In.	Yrs.	In.	
January	10	1.96	10	1.96	
			50	2.61	
			100	2.82	
	35	3.19	10	2.47	
			50	3.29	
			100	3.56	
	86	3.25	10	2.26	
			50	3.05	
			100	3.30	
July	10	2.39	10	2.59	
			50	3.37	
			100	3.68	
	35	6.04	10	4.19	
			50	6.33	
			100	6.91	
	86	6.04	10	3.87	
			50	5.61	
			100	6.11	

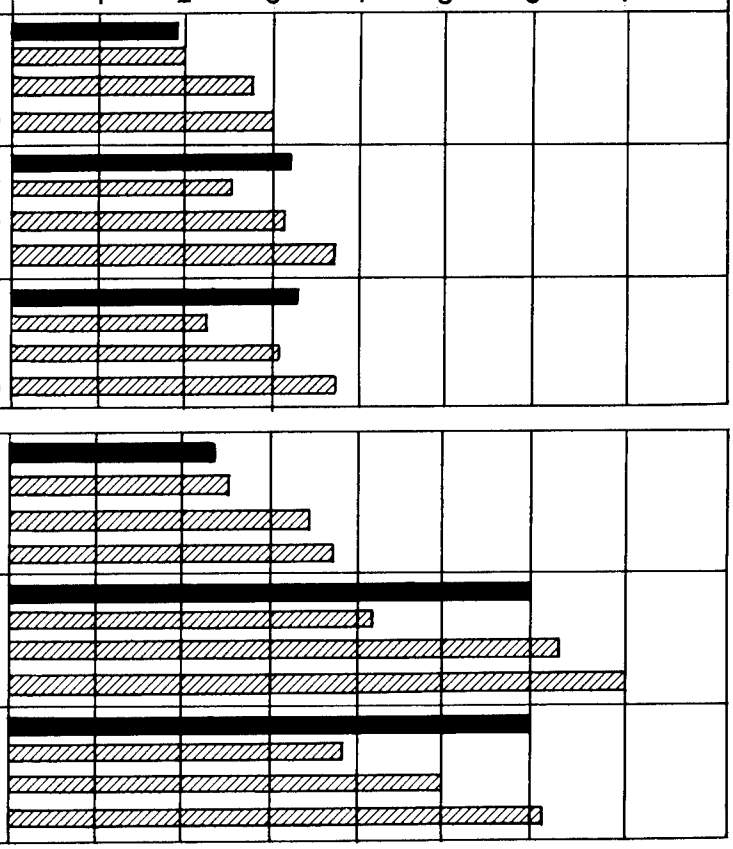


Figure 6: The black bars show the recorded 1-day maxima for 10, 35, and 86 years for January and July, respectively. The shaded bars indicate the 1-day maxima predicted for 10, 50, and 100 years. Boston is one of the ten stations used in constructing the multiple nomograph of North America; it was used in making the predictions.

inches for a 100-year period compared to only 3.87 inches for a 10-year period. The 100-year prediction (6.11 inches) exceeds slightly the maximum amount recorded (6.04 inches) for the 86-year period for the same month.

A paper on the subject was presented at a professional meeting (39). The use and accuracy of the method are being described more fully in a technical report that is nearing completion.

(3) Daily Maximum Temperature Probabilities

A multiple nomograph for predicting daily maximum temperature frequencies was developed and tested. It is based on 10-year records for 10 widely distributed stations in the United States. Statistical tests were made on comparable data of 10 additional stations selected at random. According to the tests, the frequency of maximum temperatures at given levels can be predicted for any place with considerable confidence. Only four temperature items for a given month are needed: mean daily maximum, mean daily minimum, extreme maximum, and length of record. Fixed values on the nomograph may be transferred to a table of constants for making predictions manually or entered on punch cards for processing mechanically.

The need for estimating maximum temperatures is directly related to a variety of problems, including requirements for clothing, storage, testing, design and operation of equipment in environments where frequency data in suitable form are unavailable.

(4) Predicting Temperature Duration

A paper was prepared presenting a new method for predicting the longest probable hourly duration above any critical temperature for any month, any place (46). The method, which includes a prediction chart, requires as input data only long-term monthly absolute maximum and minimum temperatures.

To eliminate any effects of season and location, all temperatures were converted to a 100 scale; 100 was assigned the 25-year monthly absolute maximum and 0 was assigned the minimum. Thus all temperatures were converted to a percent-of-range temperature regardless of the actual temperature. These converted values were plotted and limits established to produce a model for predicting durations of temperature. Statistical testing of the model was accomplished by comparing it with a similarly prepared model constructed from 100 randomly-chosen station months; the results indicated good correlation between the two sets of data.

Indiana State College, Terre Haute, Indiana, is preparing, under contract, world maps of hourly durations of critical temperatures of the hottest and coldest months for a median year. The contract also includes the preparation of maps for the hottest and coldest conditions in 5- and 10-year periods.

(5) Windchill Frequency Prediction

The windchill frequency prediction chart, first published in the cognizance report of 1958, was based on temperature and wind speed records for January. The original prediction model was later revised, expanded, and published as Technical Report EP-143, A Method of Predicting the Frequency Distribution of Windchill, January 1961. During the past year, further research on the climatic records of two Alaskan stations indicated that the method works equally well for all months. The method can be used in conjunction with windchill maps based on monthly averages of temperature and wind speed to produce windchill frequency probability maps.

(6) Cold Temperature Variability Maps

Sixty-four maps of Canada, 78 overlays, and 13 graphs on cold temperature variability during January were prepared. The series of maps, based on a 15-year record, pertains to eight significant temperature levels (-20, -25, -30, -40, -50, -60, -65, and -70°F). The maps present a method for expressing temperature variability in a manner that simplifies decision-making for staff personnel and field commanders concerned with setting up design criteria and military operations.

This technique has a wide variety of applications. They vary from an estimate of the odds that can be expected due to unfavorable or favorable temperature conditions to the freeze and break-up dates of lakes and rivers or the beginning or ending of monsoons.

(7) Tent Heating Guide

A preliminary "Tent Heating Guide" was prepared for North America for January and July. It shows by isoline the estimated rate of fuel consumption per month for all parts of the continent for each of three standard tents: (1) the Jamesway, (2) medium maintenance tent, and (3) Nike-Hercules launcher shelter (Fig. 7). A field test of the guide is needed to correct the assumptions of hours of normal operation at specified temperatures. Provided adequate data are available, guides can be developed to show estimated fuel consumption for each month for any tent on any continent.

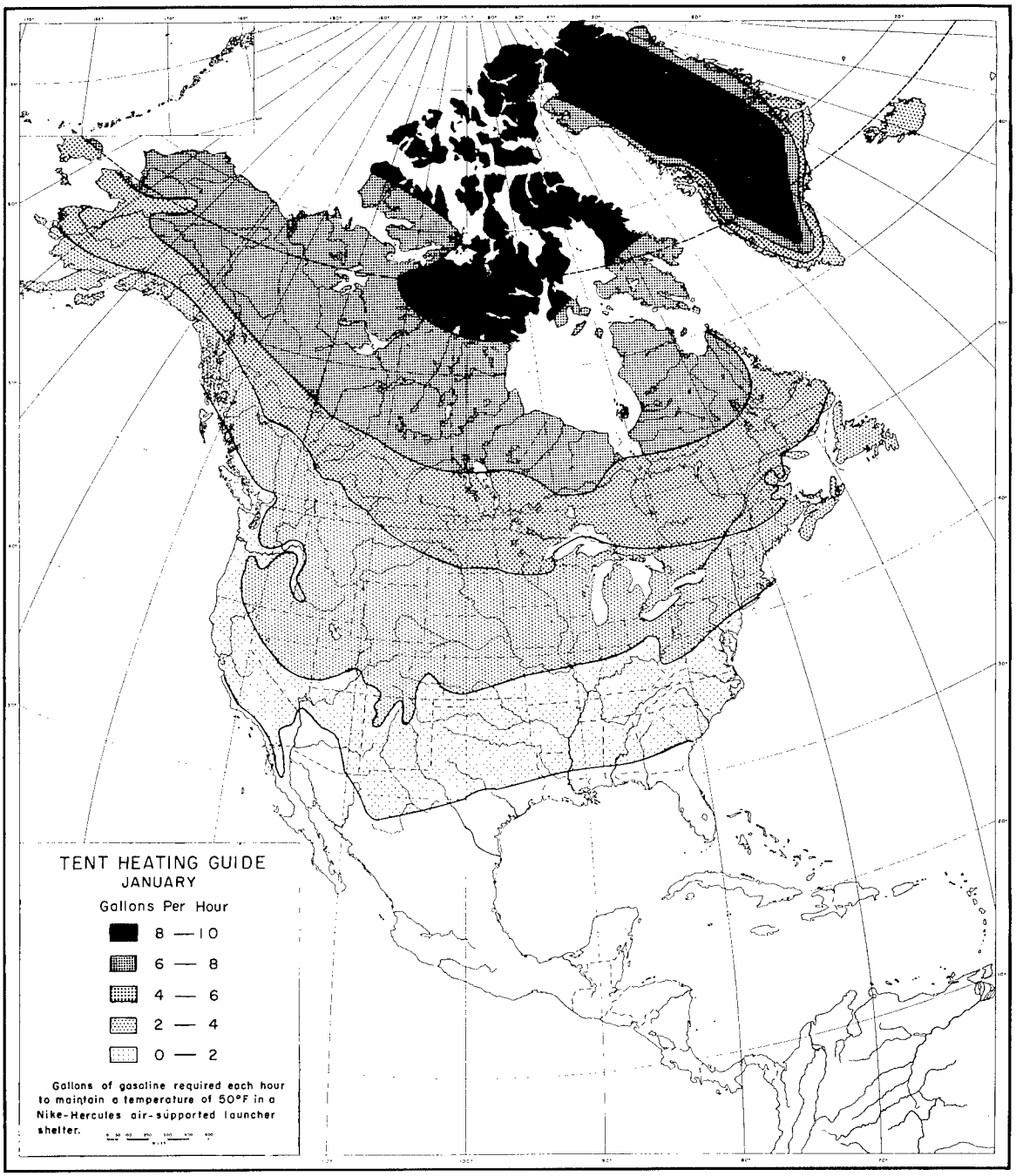

TENT HEATING GUIDE
JANUARY
Gallons Per Hour
8 — 10
6 — 8
4 — 6
2 — 4
0 — 2
Gallons of gasoline required each hour to maintain a temperature of 50°F in a Nike-Hercules air-supported launcher shelter.

Figure 7

d. Geographical and Climatological Advisory Services

In addition to the applied environmental research conducted under the planned research program, geographical and climatological studies, assistance, and guidance are provided in response to special requests and/or requirements. Since most of the varied requests cannot be forecast or included in a program and require relatively short-time effort, it is inappropriate to describe them under separate headings. The time required to furnish the requested information may vary from a few hours to several months. The immediate need for the information and also its specialized nature limits distribution of the findings to user. A few examples of the advisory services accomplished during the year are described briefly.

(1) Assistance to Army Research Office

A series of climatic maps depicting the monthly distribution of mean daily maximum temperature is being prepared at the request of the Army Research Office. The map series for Europe and Australia is almost complete. These, together with similar maps prepared previously, will be included in a companion atlas to the Atlas of Mean Daily Minimum Temperatures, published in 1960.

(2) Assistance to Other QMC Divisions

Field support was given to the Engineering Psychology Laboratory, Pioneering Research Division, in selecting a training and testing area with representative tropical environments in which suitable facilities and logistical and administrative support could be made available. Surveys were made in Puerto Rico, Canal Zone, Hawaii, and in the Philippine Islands.

At the request of Pioneering Research Division, a summary of major food crops in tropical areas of the world was prepared. The report will be used in selecting foods for a study of chemical composition, nutritional value for U.S. soldier consumption, and possible synthesis. Particular attention was devoted to the more important starchy staples, such as manioc (cassava), breadfruit, plantain, yams, and other root crops.

Environmental information and wind data within 500 feet of the surface were furnished to the Air Delivery Equipment Division to determine design criteria for low-altitude parachute drops.

At the request of the Clothing and Organic Materials Division, a compilation of data on mean daily maximum and minimum temperatures and relative humidities was prepared for a number of meteorological stations

situated at or near Army installations in the United States. These data were used to evaluate surveillance inspection reports on clothing and plastic items stored in Army warehouses.

(3) Revision of AR 705-15

In response to directions from the Army Research Office, work has continued on the revision of AR 705-15. With the cooperation and assistance of the other Technical Services, the Quartermaster Corps completed a draft revision that includes revised "Climatic Design Criteria" and a new section on "Design Criteria for the Atmosphere from the Surface to 30 Kilometers." Also, a draft of a new regulation covering Army support to scientific expeditions was completed. The environmental design criteria section is planned for expansion to include terrain.

e. Support to Scientific Expeditions

Under the continuing program for providing support to scientific expeditions, monitored for the Army by the Quartermaster Corps, support was continued for three expeditions during the year, two new expeditions received Army support, and arrangements are being made to support two others.

The Mt. McKinley Range Expedition, led by Mr. Adams Carter, was given support consisting of equipment furnished by the Corps of Engineers. This expedition, carrying out a glaciological research program on the Eldridge Glacier, furnished a final report consisting of reprints from the Journal of Glaciology, Vol. 3, No. 30, entitled: "Milton Mt. McKinley Range Expedition, 1960".

Support in the form of equipment was also continued for an expedition to the Antarctic sponsored by the University of Wisconsin. This expedition is studying the rate of growth of ice wedges and sand wedges, the factors that influence their growth, and their usefulness in dating geomorphic events such as the retreat of glacial fronts.

The Devon Island Expedition sponsored by the Arctic Institute of North America continued to receive support for its overall scientific program. Additional rations and equipment were furnished for operations during the summer of 1962. A preliminary report of the 1961 operations appears in the December 1961 issue of Arctic.

An expedition to the Mt. St. Elias range in Canada, also sponsored by the Arctic Institute of North America, received support in the form of meteorological equipment.

The American Institute of Biological Sciences is receiving financial support jointly from the expeditions program and from the Surgeon General's Office for an expedition to King Karl Island off Spitsbergen. This expedition will make studies on marine biology and of the polar bears on this arctic island, ideally suited to the purpose.

Two other expeditions have been approved for support by the Army Research Office and negotiations are underway to supply equipment for a solar radiation observation program in East Africa and for a geographical study of the savanna areas in British Guiana.

7. Signal Corps

a. Meteorological Support to Army Research and Development Activities

The Signal Corps provided meteorological teams at 15 sites from Alaska to the Canal Zone for observation and collection of meteorological data in support of R&D activities, including environmental research programs. Support was provided to the Quartermaster Corps in the Canal Zone; in Greenland; at Fort Huachuca and Yuma, Arizona; and at Natick and Maynard, Massachusetts. In addition, meteorological support to the Quartermaster Corps was provided in Hawaii, by cross-service order to the Weather Bureau, for tests on the effects of radiation. Other sites at which meteorological data were collected in support of Army Technical Services, R&D activities included Dugway, Utah; Edgewood, Maryland; Houghton, Michigan; Fort Monmouth, New Jersey; Redstone Arsenal, Alabama; White Sands Missile Range, New Mexico; Fort Churchill, Canada; and Fort Greely, Alaska

b. Meteorological Research

Under its assignment of primary cognizance for Research and Development in the field of meteorology, the Signal Corps is conducting several programs, the results of which will contribute significantly to a better understanding of the environment and to the Army's future capability for conducting environmental research. Publications in this field are listed in the reference sections of the DD Forms 613 (1 April 1962) for the Signal Corps meteorological projects and tasks. These programs are briefly described below:

(1) Arctic Meteorological Research

This work includes basic research required to understand those meteorological phenomena and processes which are peculiar to arctic and polar areas. These include such phenomena as whiteout, the stability of the atmosphere over icecaps, the lack of atmospheric aerosols, and the contribution of the arctic areas to the earth's energy balance, etc. The program is designed to develop a knowledge of arctic and polar meteorology that would be useful in Army arctic operations.

(2) Tropical Meteorological Research

This effort in basic research is directed toward understanding the meteorological phenomena and processes peculiar to tropical areas. The objective is to develop new knowledge of tropical meteorology for Army use. Effort to identify and establish the meteorological aspects of the environment for different types of tropical regions, i.e., rainy tropics, wet-dry tropics, monsoon tropics, tropical deserts, and tropical highlands, was significantly increased.

(3) Low Level Wind Research

This work covers basic research required to understand and correct for the low level winds in the launching of free rockets. The results of this basic research into the structure and behavior of low level wind, and its variability with time and space are applicable to many environmental problems. The program during the report period has been along the lines of (1) research in the physical and dynamic processes involved in low level winds; terrain effects on these winds; vertical movements; turbulence and local circulation; (2) a re-evaluation, under new conditions, of known techniques for measurement of low level winds; (3) exploration of new techniques for measuring low level winds; and (4) determination of the "representativeness" of low level wind measurements.

(4) Small-Scale Meteorological Research

This effort covers the basic research required to understand the physical processes of local exchange of energy between the atmosphere and the earth's surface, and the local phenomena and meteorological conditions created by this exchange. This exchange of energy causes local modifications in the large-scale meteorological conditions; and meteorological variations thus produced are important to many Army operations. These variations are caused by differing terrain features, soil types, and vegetation as well as other factors. A better understanding of these local variations will contribute directly to the environmental research program. Work was primarily by outside contracts. Internal efforts involved the employment of analog computers to develop simulation models and to study the interrelationship of the various meteorological parameters involved.

(5) Instrumentation Development

Many environmental factors, created or influenced by meteorological conditions, cannot be successfully studied because of inadequate instrumentation for measuring reliably and accurately the meteorological parameters involved. In many meteorological parameters, such as soil temperature, soil moisture, desert and arctic humidities, high altitude probing, atmospheric particulate matter (dust, salt, etc.), discrimination in the spectrum of radiation, turbulence and wind shear, present meteorological instrumentation is far from adequate for research purposes. Automation of existing meteorological measurements and development of equipment which does not require attendant manpower, is also an urgent requirement to facilitate the collection and analysis of meteorological data for environmental studies. Activities were continued in the development of new equipment and in improvement and automation of existing equipment for measuring those meteorological parameters used to describe or study the environment.

(6) The Electronic Environmental Test Facility

The Signal Corps continued implementation of the Electromagnetic Environmental Test Facility in southern Arizona. While this facility will be used primarily to measure and study the electromagnetic environment in which the Army operates, the terrain and meteorological studies necessary to support the investigation of the electromagnetic environment will, as a by-product, contribute to the Army's environmental research program.

(7) Upper Atmosphere Research

The Signal Corps has significantly increased its effort in upper air research. The objective of this program is two-fold: to achieve a better understanding of the dynamics and thermodynamics of the upper atmosphere to improve the state of the science in meteorology and atmospheric physics; and to establish environmental design and test criteria in the upper atmosphere for Army rockets, missiles, aircraft, and instrumentation for sounding the upper atmosphere. The environmental parameters requiring establishment in the upper atmosphere include temperature, humidity, wind speed, turbulence, wind shear, chemical and electrical characteristics.

Two specific phases of this upper air research program, as it affects environmental research, are now under way. Each of these is described briefly below:

a. Summarized atmospheric data up to 100,000 feet suitable for environmental design and test criteria already exist for many parts of the world. Since AR 705-15 is being revised to include a section on upper atmospheric environmental design and test criteria, the Signal Corps is collecting and collating the available data required to establish these environmental criteria.

b. Atmospheric data above 100,000 feet are extremely inadequate for either understanding the atmospheric processes above that level or for establishing environmental design and test criteria. Until recently, the use of balloon-borne instruments with a maximum altitude of approximately 100,000 feet was the only operational technique in general use for sounding the atmosphere. With the advent of satellites, soundings are now possible above 500,000 feet. Between the balloon-borne instrument level of approximately 100,000 feet and the satellite level of 500,000 feet and above, there is an important gap in our knowledge of environmental design and test criteria for the upper atmosphere. The Signal Corps has sponsored an initial effort to fill this gap by use of small meteorological rockets which now attain altitudes between 100,000 and 300,000 feet. The Signal Corps, assisted by USAF, USN, and NASA, has

established a network of six sites for collection of upper atmospheric data by firing meteorological rockets. These sites are Fort Greely, Alaska; Point Mugu, California; White Sands Missile Range, New Mexico; Patrick Air Force Base, Florida; Wallops Island, Virginia; and Fort Churchill, Canada. Results from these sounding rockets have been collected and are being analyzed to provide both meteorological and environmental information on high altitude atmospheric conditions. It is expected that this program will continue until the collection of data are adequate for understanding the dynamic and environmental characteristics of the atmosphere between 100,000 and 300,000 feet. New meteorological rocket firing sites will be incorporated into this program during the coming fiscal year. This program has now become a joint-agency national project.

(8) Atmospheric Hydrometeor and Lithometeor Studies

Atmospheric hydrometeors and lithometeors affect environmental research and testing from ground levels up to 50,000 feet or more. Water vapor, dust, salt particles, chemicals, etc., in the atmosphere near the ground, are important factors in local environmental conditions; but, equally important to the Army missile program, the frequency of occurrence and size of various forms of precipitation at higher altitudes are hazards in the environment through which Army rockets and missiles must pass. Rocket nosecones are sometimes damaged by the impact of hail and large raindrops to a point where the aerodynamics of the rocket may be altered or a warhead may be prematurely detonated. The establishment of statistical values of these parameters has been neglected in the past since they were not considered to be environmental factors under the usual understanding of the term and since their importance was not fully realized until the advent of rockets and missiles. The Signal Corps has started a program of investigation and data collection which will ultimately make it possible to firmly establish these unique environmental criteria.

8. Transportation Corps

Environmental activities in the Transportation Corps (TC) are carried out by the U.S. Army Transportation Research Command (USATRECOM) and the U.S. Army Transportation Board (USATB), both located at Fort Eustis, Virginia. USATRECOM is responsible for environmental research within the Transportation Corps, consisting largely of efforts designed specifically to meet the needs of TC mobility and hardware projects. USATB is assigned an operating mission closely related to environmental research, which is to "provide transportation support for military activities in difficult environments and to conduct operations leading to improvement of operating capabilities in difficult environments." Broadly, the global scope of existing and potential TC surface and Army air operating commitments leads to a large TC consumer requirement for environmental and geographic information.

USATRECOM, USATB, and the USA Transportation Combat Development Command presented a series of papers at a meeting of the Panel on Environmental Research in October 1961 at Fort Eustis, Virginia. The papers pertained to the environmentally oriented projects and activities of the Transportation Corps.

a. Basic Research Studies

Northwestern University completed the second year of research under a 5-year USATRECOM program to develop new concepts and theories concerning the underlying relationships of physical, economic, and population influences that regulate the character and development of transportation resources, particularly in underdeveloped areas (14).

b. Tropical Research

USATRECOM's tropical studies were made to obtain a better understanding of the geographic and environmental factors affecting transport movement and mobility. A contract team consisting of a botanist, physical geographer, and mobility engineer made a brief survey of El Chepo area of Panama and observed USATB's off-road movement of Swamp Fox I operation. The team completed a coordinated report of the environmental-mobility factors observed.

c. Antarctic Operations

In operation Topo-Antarctica, two USATB air and ground helicopter crews furnished the aviation support needed by survey teams to establish ground position control for aerial photo maps of the mountains on the west coast of Ross Sea (29). The partially snow-free area surveyed extends southward from near Cape Adare (lat. 72°S.) to the head

of Beardmore Glacier (lat. 86°S.). The surveyors used theodolites for angle measurements and Tellurometers (electronic distance measuring devices) as primary survey equipment. Sixty-eight prominent sites at approximately 20-mile intervals were occupied and surveyed in the 1,510-mile traverse, involving mostly mountain-top landings and take-offs at elevations to 13,500 feet (Mt. Usher). Accurate topographic data were acquired for 100,000 square miles of previously unmapped, or partially charted, terrain. The difficult work was accomplished in the short but frequently interrupted period from 6 November 1961 to 12 January 1962. The supporting HU-1B Iroquois helicopters contributed appreciably to the success of the surveying mission, operating predominantly within a temperature range of 0 F to -28 F; all normal maintenance was done under field conditions. The lower temperatures occurring at higher elevations were accompanied by persistent winds of 20 to 30 miles per hour.

d. Tropical Operations

USATB carried out the experimental, off-road Swamp Fox I operation in the Darien Province of Panama, south of the Canal Zone, during the period 20 August to 30 September 1961 (28). In this operation, 50 officers and men used 14 high-mobility vehicles in a 150-mile traverse from a terminus of the Inter-American Highway (45 miles south of the Canal Zone) to the village of Santa Fe on the Rio Sabana. Vehicular movement over the savanna and rainforest trails and trace-roads during the rainy season demonstrated numerous environmental problems. These include soft, sticky soils; V-notched valleys; slippery slopes; high, steep stream banks; much vegetation obstruction and snagging; difficult helicopter flight conditions and lack of landing sites. Further study and testing in similar wet tropical environments are needed. Thirty-six observers from 17 agencies visited the operation during its various stages.

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APPENDIX 1

DEPARTMENT OF THE ARMY
General Staff, United States Army
Washington 25, D.C.

CSGLD/F1 28507 10 June 1949

MEMORANDUM FOR: Chief of Ordnance
Chief of Engineers
Chief of Transportation
Chief, Chemical Corps
Chief Signal Officer
The Quartermaster General
The Surgeon General
Chief, Army Security Agency
Chief, Army Field Forces

SUBJECT: Assignment of Research and Development Cognizance in the Fields of Cryological Phenomena, Meteorology, and Environmental Research

1. References:

a. Memorandum, this office, subject: "Definition of Primary Cognizance as applied to Research and Development Activities," dated 24 November 1948.

b. RDB 165/2.1 (with attachments) wherein the RDB assigned primary responsibility for research and development in the field of snow, ice and permafrost on and beneath the land surface (except the littoral) to the Department of the Army.

c. RDB 133/2, "Statement or Policy and Allocation of Responsibility for Research and Development Programs," as supplemented by RDB 133/3 and RDB 133/4.

2. a. Primary cognizance for research and development in the field of cryological phenomena pertaining to snow, ice and permafrost on and beneath the earth's surface is assigned to the Chief of Engineers. This assignment includes responsibility within the National Military Establishment for research and development pertaining to cryological phenomena on and beneath the land surface (except the littoral) as assigned to the Department of the Army by the Research and Development Board in Reference 1 b above.

b. In addition to the responsibilities outlined in reference 1 a above, the additional responsibilities of the Department of the Army as set forth in paragraph 5 of reference 1 c above are delegated to the Chief of Engineers. The Chief of Engineers will insure that all questions of individual departmental responsibility are either settled by mutual agreement, or in the event of disagreement, are submitted to the Deputy Director for Research and Development for decision. Disagreements to such decisions will be referred by the proposing department to the Research and Development Board for resolution.

c. The Chief of Engineers is charged with keeping the Departments of Navy and Air Force fully advised of the current status and progress in this field and will maintain direct liaison for that purpose.

3. a. Primary cognizance for research and development within the responsibilities of the Department of the Army in the field of meteorology is assigned to the Chief Signal Officer. Meteorology is defined as the science or that branch of physics which treats of the physical, chemical, and electrical parameters of the entire gaseous envelope of the earth, such as composition, wind, pressure, temperature, humidity, and the various phenomena associated therewith, including all theoretical, synoptic and instrumental aspects of the same. This assignment does not include the application of meteorological data to non-meteorological techniques, such as sound-ranging, electro-magnetic wave propagation, and specialized environmental studies except when such techniques are used as meteorological tools.

b. No assignment of research and development responsibility for the subject field has been made by the Research and Development Board.

4. a. Primary cognizance for research and development within the responsibilities of the Department of the Army in the field of Applied Environmental Research is assigned to the Quartermaster General. Applied Environmental Research is defined as the collation of statistical, meteorological, climatic, and geographical data as accumulated by the responsible agencies, the interpretation of these data, and the presentation of the evaluated information in suitable form for application by appropriate agencies to logistics problems of equipment, personnel, and operational functions. This assignment excludes the field of snow, ice and permafrost as covered by paragraph 2 a above.

CSGLD/F1 28507
SUBJECT: Assignment of Research and Development Cognizance in the Fields of Cryological Phenomena, Meteorology, and Environmental Research

b. No assignment of research and development responsibility for the subject field has been made by the Research and Development Board.

5. The War Department Research and Development Program for Fiscal Year 1949, The Department of the Army Research and Development Program for Fiscal Year 1950, and The Department of the Army Research and Development Plan for Fiscal Year 1951 are amended accordingly.

BY ORDER OF THE UNDER SECRETARY OF THE ARMY:

C. G. HELMICK
Major General, GSC
Deputy Director for
Research and Development
Logistics Division

APPENDIX 2

FILE NO.
G4/F2 41949 SUBJECT: Transfer of Six Army-Wide Environmental Research Projects to THE QUARTERMASTER GENERAL

TO The Quartermaster General FROM G4 DATE 30 June 1952 COMMENT NO. 1
ATTN: Military Planning Division Dr. Paul A. Siple/53665/kjw
Research and Development Branch

1. An evaluation of the Environmental Research Programs of the Army reveals that several requirements exist within fields of cognizance assigned to you which are not currently included in any program. They are:

a. Research on techniques of application of environmental knowledge to Army-wide military problems.

b. Support of Environmental and Geographic Research on Geographic Expeditions and other field projects not specifically organized by agencies of D/A. The interests of all D/A agencies are included in this project. This financial support does not conflict with existing policies for expedition support but is supplementary to them.

c. Establishment of rapid system for the analysis of performance of Army equipment under all environmental conditions following the principles of recommended in ORO-R-4, dated 12 July 1950, (Project ENVANAL).

d. Development of a system whereby military areas can be analyzed in terms of environmental stresses, and results organized in a form adaptable to machine tabulation. This will be the basic information against which the performance of Army equipment will be evaluated by the rapid system in c above, permitting a regional evaluation of the capabilities of military equipment in the form of logistics and operations almanacs.

e. Prepare recommended D/A policies establishing design criteria for performance of Army equipment and materiel under adverse conditions of environment similar to SR 705-70-5.

f. Research on radical methods of improvement in protection of personnel from environmental stresses. This project is intended to support new scientific concepts which if successful, may be important, but practicability of application cannot be assured from present knowledge of the subject.

2. The responsibility for conducting research on these problems is hereby assigned to The Quartermaster General.

3. Funds in the amount of $479,000, have been included in the FY 1953 Army-wide research budget to cover these projects. A similar amount is included in the FY 1954 Army-wide research budget for continuance of these projects. Subsequent funding actions on budgets beyond FY 1954, are the responsibility of your office. Upon availability, funds referred. to will be transferred to The Quartermaster General. The assignment of technical objectives and division of funds is as follows:

PROJECT NO.		TECHNICAL OBJECTIVE	BUDGET PROJECT	FUNDED IN FY 1953
*a. 0X8305001Z	Research on Applications of Environmental Techniques	10-16	1520	$50,000
b. 0X8303002Z	Support of Environmental and Geographic Research on Geographic Expeditions and other Field Projects not specifically organized by Agencies of D/A.	10-16	1520	$100,000
c. 0X8305002Z	Establishment of Machine Tabulation System of Recording Equipment Performance under Specific Conditions of the Environment (ENVANAL)	10-16	1520	$150,000
d. 0X8303001Z	Development of Techniques and Establishment of Geographic Base for "Logistics and Operations Almanacs".	10-16	1520	$100,000
e. 0X8301001Z	Research for Establishment of Army-wide Environmental Design Criteria Standards	10-16	1520	$29,000
f. oX8301005Z	Research on and Development of Radical Improvements in Environmental Protection of Personnel	10-16	1520	$50,000

*This is a continuation of FY 1952 project previously transferred to your office.

G4/F2
SUBJECT: Transfer of Six Army-wide Environmental Research Projects to The Quartermaster General

4. Due to the Army-wide interest in these projects, monitorship will be maintained by General Staff. The primary contact for General Staff is Dr. Paul A. Siple, OACofS, G-4, Research and Development Division, Research Branch, (Chairman, Department of the Army Committee on Environmental Factors and Control). Coordination with interested agencies will be maintained by the project officer, OQMG.

5. Background data pertaining to these projects is located in Dr. Siple's office, Room 3B-480, The Pentagon, and are available to your personnel for inspection and transfer, if desired.

6. It is requested that steps be taken at this time to initiate formal projects for inclusion in your research and development program.

/s/ MICHAEL BUCKLEY, JR.
Colonel, GS
Asst. Dep. ACofS, G-4, for
Research & Development

APPENDIX 3

R&D DIR 335-1

R&D DIRECTIVE)
)
NO. 335-1)

HEADQUARTERS
DEPARTMENT OF THE ARMY
OFFICE, CHIEF OF RESEARCH AND DEVELOPMENT
Washington 25, D. C. 24 May 61

REPORTS
Applied Environmental Research Program Report
(RCS CSCRD-23)

(Effective Until 23 November 1962 Unless Sooner Rescinded or Superseded)

1. GENERAL

This directive provides instructions for preparation of the Department of the Army annual report on applied environmental research. This report is for the use of the Army General Staff and its research and development agencies, and the Army technical services. It is also used by the Army Committee on Environment and the Environmental Research Subpanel, Army Scientific Advisory Panel. The report provides technical and planning information required for the supervision, coordination, and long range programming of Army efforts in applied environmental research. It also summarizes army accomplishments in the field of applied environmental research.

2. RESPONSIBILITIES

a. The Quartermaster General will compile the annual report, utilizing his own material together with material contained in feeder reports supplied by the other technical services. The annual report will be prepared as of the end of the fiscal year and dispatched to the Chief of Research and Development no later than 40 working days after the end of the fiscal year.

b. Heads of technical services will prepare contributions to the annual report describing their respective programs. These feeder reports are to be dispatched to the Quartermaster General each year no later than 20 work days after the end of the fiscal year.

c. Information included in the annual report may be referred to, but need not be included in, the RDT&E Project (Task) Card (RCS CSCRD-1(R2)).

R&D DIRECTIVE NO. 335.1
SUBJECT: Applied Environmental Research Progress Report (RCS CSCRD-23)

d. The annual report will be prepared in accordance with Inclosure 1. Each technical service will contribute specifically to those sections dealing with its accomplishments in this field as well as to appropriate sections of a general nature reflecting overall Army accomplishments in applied environmental research. (CRD/M.)

BY DIRECTION OF THE CHIEF OF RESEARCH AND DEVELOPMENT

1 Incl
Instructions

JOHN K. BOLES, JR.
Colonel, GS
Executive

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Commandant, Air Research and Development Command	1

DEPARTMENT OF THE NAVY

Chief, Bureau of Supplies and Accounts	1